The phytosociology and structure of vegetation near Villa Nora, north-western Transvaal, South Africa

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The phytosociology and structure of the woody layer of the Mixed and Arid Sweet Bushveld near Villa Nora, north-western Transvaal, is presented. Relevés were compiled in 46 stratified random sample plots. The Braun-Blanquet procedure and Variable Quadrant Plot Method revealed three distinct plant communities, two sub-communities and six variants which correlated with soil type. A hierarchical classification, description and ecological interpretation of the vegetation units are presented. The results of a DECORANA ordination corroborate the vegetation units and associated ecological interpretation of the Braun-Blanquet classification. Three areas uniform in vegetation and soil type were identified as suitable management units for game ranching.

Die fitososiologie en struktuur van die houtagtige stratum van die Gemengde en Dorre Soetbosveld naby Villa Nora, Noordwes-Transvaal, is ondersoek. Relevés is in 46 gestratifiseerde ewekansig gekose monsterpersele saamgestel. Die Braun-Blanquet-prosedure en Variërbare-kwadrantperseelmetode toon drie duidelik onderskeibare plantgemeenskappe, twee sub-gemeenskappe en ses variante wat korreleer met grondtipe. 'n Hiërargiese klassifikasie, beskrywing en ekologiese interpretasie van hierdie plantegroei-eenhede word aangebied. Die resultate van 'n DECORANA-ordening stem ooreen met die plantegroei-eenhede en geassosieerde ekologiese interpretasie van die Braun-Blanquet-klassifikasie. Drie gebiede wat eenvormig in plantegroei en grondtipe is, is geïdentifiseer as geskikte bestuurseenhede vir wildboerdery.

Keywords: Braun-Blanquet classification, bushveld, synecology, DECORANA, management units.

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Introduction

Over the past twenty-five years the keeping and commercial utilization of game on private land in South Africa has increased considerably (Bothma 1990; Peel *et al.* 1991). To date, however, most research relating to game management has dealt with conservation aspects in national parks and nature reserves, with little research being done on game ranches (Peel *et al.* 1991). This has, in many cases, led to the deterioration of veld on game ranches owing to mismanagement (Grossman 1988).

The delineation of homogeneous vegetation units is essential for ecologically sound veld management (O'Reagan & Turner 1992). In the north-western Transvaal Bushveld, little knowledge exists of the nature and distribution of vegetation (Van Staden 1992). In the vicinity of Villa Nora only broad-scale vegetation classifications have been conducted (Irvine 1941; Coetzee 1971; Acocks 1988). In the present study a detailed classification of vegetation into floristically and structurally homogeneous units is given, on which broader management units are based to facilitate ecologically sound game ranch planning and management.

Study area

The study area comprises Rhino Ranch, a 2066-ha game ranch situated approximately 40 km east of Ellisras, about 2 – 3 km from Villa Nora. The area is situated between 28°00′ and 28°05′ E longitude and 23°30′ and 23°34′ S latitude, in the transition zone between Arid Sweet Bushveld and Mixed Bushveld (Acocks 1988; Veld Types 14 and 18, respectively).

The altitude of the study area ranges from 880 m in the north to 920 m in the south. The topography is flat with a slope of less than 2°. Several non-perennial streams drain from the study area into the Lephalala River which is 6 – 7 km to the east. The rock substrate belongs to the Bushveld Complex and is represented by the Rustenburg Layered Suite, which consists of anorthosite and gabroid rock, and the Lebowa Granite Suite, which consists of coarse-grained granite (Van der Walt 1978). The anorthosite and gabroid rock has weathered to form deep clay soils of the Hutton and Arcadia soil forms, and the coarse-grained granite has weathered to form shallow, relatively sandy, soils of the Mispah soil form (Schmidt 1992). A narrow diabase dyke runs below a small section of the coarse-grained granite (Van der Walt 1978).

The mean annual rainfall for the Villa Nora rainfall station (station number 0675 1829; 28°07′ E and 23°32′ S; 844 m) for the period 1909 – 1990 is 437.8 mm (Weather Bureau, Department of Environment Affairs, Pretoria). The wet season has its peak rainfall in January while the dry season stretches from April to October. The daily mean minimum and maximum temperatures are 6.4 and 32.9°C, respectively.

Methods

Eight structural-floristic stratification units were subjectively identified and mapped with the aid of a stereoscope and 1:30 000 aerial photographs. Relevés were compiled in 46

stratified random sample plots. The number of sampling plots per stratification unit was never less than three.

The size of the sampling plots and the data collected in them depended on whether the herbaceous or woody component was being sampled. In accordance with Coetzee *et al.* (1976), sample plots were fixed at 200 m^2 for the herbaceous layer. The total floristic composition was noted and Braun-Blanquet cover abundance values were accorded to each species (Mueller-Dombois & Ellenberg 1974). The size of the sample plots for the woody layer was determined according to the Variable Quadrant Plot Method (Coetzee & Gertenbach 1977) and the number of individuals of a species and the canopy diameter of each individual were noted in six height classes. Braun-Blanquet cover abundance values (Mueller-Dombois & Ellenberg 1974), density and percentage canopy spread were determined for the woody species from these data [see also Coetzee (1982) and Van Rooyen (1983)]. Environmental data recorded at sample sites included soil type, depth, texture, colour, pH and surface erosion, geology and degree of utilization by herbivores (Schmidt 1992).

The Braun-Blanquet procedure [see also Bredenkamp *et al.* (1989); Kooij *et al.* (1990); Fuls *et al.* (1992)] was applied to the combined herbaceous and woody floristic data matrix to derive a classification of vegetation types. A Detrended Correspondence Analysis (DECORANA) (Hill

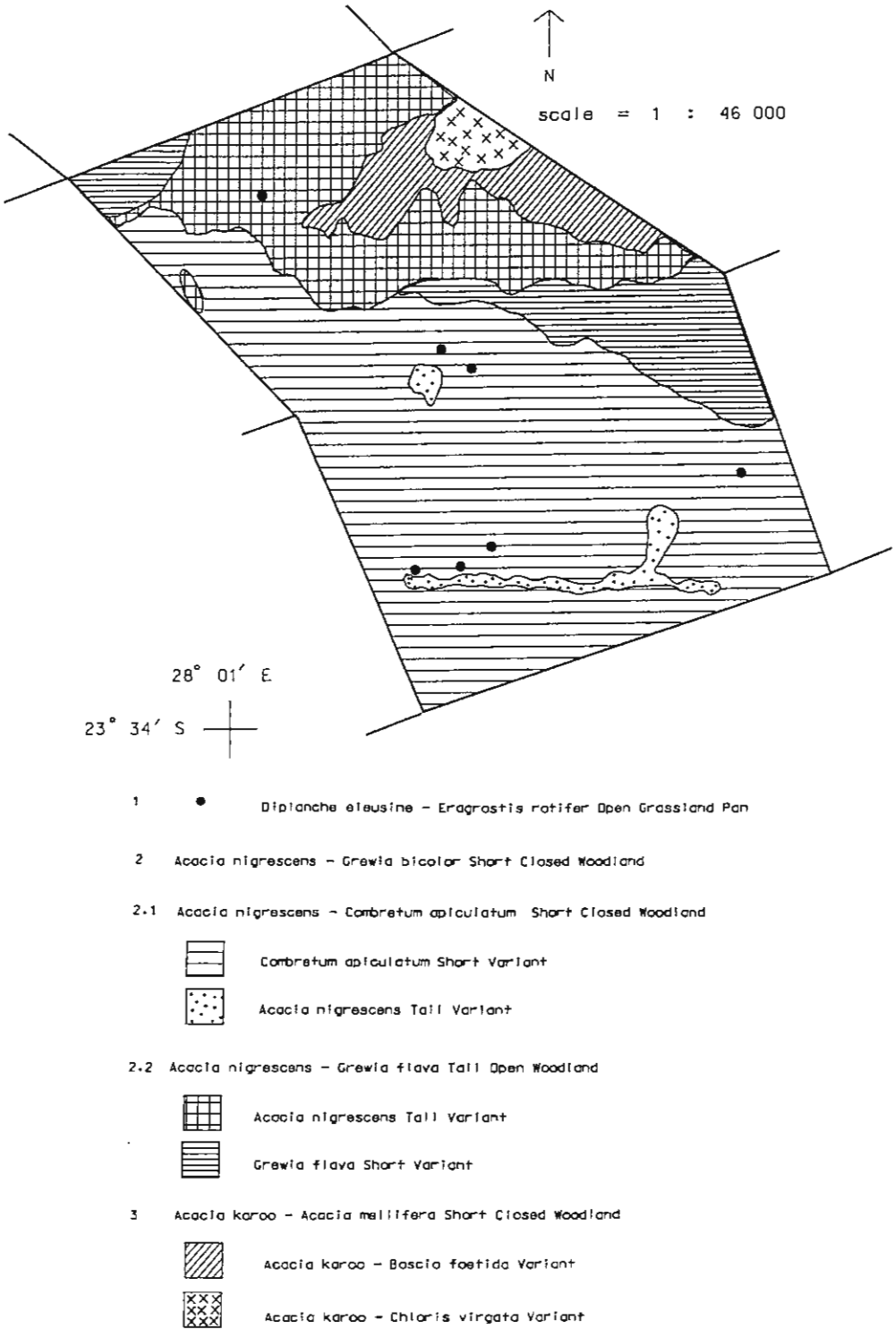

Figure 1 A vegetation map of Rhino Ranch, north-western Transvaal.

1979) was applied to the floristic data to determine probable vegetation gradients.

Taxa names conform to those of Gibbs Russell *et al.* (1985, 1987). The nomenclature of vegetation units up to the level of sub-community is based on recommendations by Edwards (1983) and Barkman *et al.* (1986).

Results

Classification

In total, 90 species were noted in the 46 relevés with an average of 24 species per relevé.

From the final phytosociological table (Table 1) and structural analyses (Tables 2 – 7), three plant communities, two sub-communities and six variants were identified and mapped (Figure 1). A diagrammatic presentation of the hierarchical classification and associated environmental interpretation of the vegetation is given in Figure 2.

Description of plant communities

1. The *Diplachne eleusine – Eragrostis rotifer* Open Grassland Pan

The pans are associated with the Arcadia Arcadia soil type (Figure 2) (MacVicar *et al.* 1977) and are represented by 3 relevés with an average of 7 herbaceous species per relevé.

The vegetation is characterized by species group A (Table 1) which includes the diagnostic species *Diplachne eleusine* and *Mariscus indicorus*. Species group K is the only other species group represented in this community and includes the dominant species *Eragrostis rotifer*, and the species *Chloris virgata, Corbichonia decumbens* and *Bothriochloa radicans*. Species group K indicates a relationship between the pan community and the herbaceous layer of all the vegetation units in the study area except the *Combretum apiculatum* Short Variant. The absence of species group K from the *Combretum apiculatum* Short Variant may be related to the much lower clay content and shallower soil of the Mispah soil form than the Hutton and Arcadia soil forms (Figure 2).

2. The *Acacia nigrescens – Grewia bicolor* Short Closed Woodland

This community occurs mostly on the Mispah Mispah and Hutton Schorrocks soil types (Figure 2) (MacVicar *et al.* 1977) and is represented by 32 relevés with an average of 27 species per relevé.

The vegetation is characterized by species group B (Table 1) which includes the diagnostic and dominant forb *Melhania acuminata* and the woody species *Acacia nigrescens* and *Grewia monticola*. Other species which are locally conspicuous are the dominant woody species *Combretum apiculatum* (species group C) and the grass *Aristida congesta* subspecies *barbicollis* (species group F).

Species groups J, K and L are also present in this community, indicating a relationship with the *Acacia karoo – Acacia mellifera* Short Closed Woodland. Species group L includes the woody species *Grewia bicolor* and the grass *Aristida adscensionis* which are dominant, and the woody species *Acacia tortilis* and *Grewia flava* which are abundant.

2.1 The *Acacia nigrescens – Combretum apiculatum* Short Closed Woodland

This sub-community is mostly restricted to the Mispah Mispah soil type (Figure 2) and is represented by 16 relevés with an average of 27 species per relevé.

The vegetation is characterized by species group C (Table 1) which includes the diagnostic woody species *Combretum*

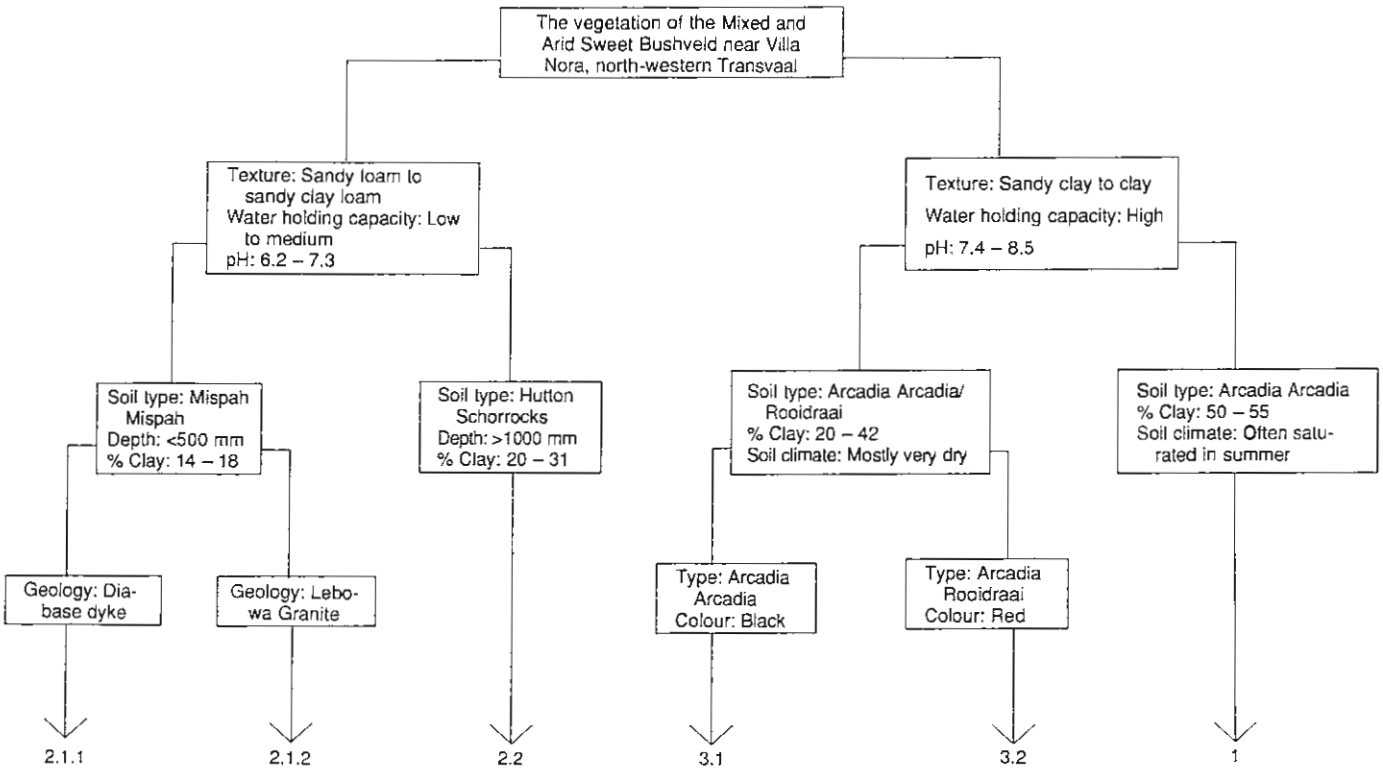

Figure 2 The hierarchical classification and associated environmental characteristics of the vegetation units on Rhino Ranch, north-western Transvaal. Numbers of vegetation units correspond with numbers and descriptions of vegetation units in the text.

Table 1 A phytosociological table of Rhino Ranch, north-western Transvaal

COMMUNITY	1		2			3	
NUMBER			2.1		2.2	3.1	3.2
			2.1.1	2.1.2			
RELEVE	444	223	2323332233422		1311111443122131	4001	0000000
NUMBER	234	252	3091357667148		4821593054801697	6790	1562483
Species Group A: Diagnostic and dominant species of the Diplachne eleusine - Eragrostis rotifer Open Grassland Pan							
Diplachne eleusine	+4+						
Mariscus indecorus	+++						
Species Group B: Diagnostic and dominant species of the Acacia nigrescens - Grewia bicolor Short Closed Woodland							
Acacia nigrescens		545	41 11+ABB13A3		A1+ 1AABA13B3454	1	+ A
Melhania acuminata		3A3	3343333535453		3A1 4+4+1+1+++1	1	+
Dichrostachys cinerea		+ +	1A111+11+++++		A++ 1AA++1++1+++		
Grewia monticola		A1	A1A11A1 +1B3B		+11 11A1 A+ B+11	+1	+
Panicum maximum		1A+	++++A+++ +++		A1A+13++ 1+1+		
Hibiscus micranthus		+++	++++++++++++		+++++ + + ++++		
Melinis repens		+	+ +1+1+ ++1 +		+++1A1+ 1B++++		
Seddera capensis		+	++ + + +++++		+ + +B ++++		
Evolvulus alsinoides		++	A1+1+A3A11A+		1++AB+A 1A+		
Urochloa panicoides		B1+	++ B + +		+++AA+A+++ +1 1		
Species Group C: Diagnostic and dominant species of the Acacia nigrescens - Combretum apiculatum Short Closed Woodland							
Combretum apiculatum		1AA	AA4A13BAAB33B		+ +		
Ruellia patula		+++	++++ +++++++		+ ++ 1		
Eragrostis rigidior		+ +	1+++11+++ ++		A+ +		
Heteropogon contortus		++	+ + + ++		+		
Species Group D: Diagnostic, dominant and conspicuous species of the Combretum apiculatum Short Variant of the Acacia nigrescens - Combretum apiculatum Short Closed Woodland							
Commiphora mollis			11 + +1 1A4+B				
Peltophorum africanum			1 1111 +1A B				
Sclerocarya birrea			1 11 B A1 B1				
Waltheria indica			+1AAB+1+++1+		+1 ++		
Pogonarthria squarrosa			++++A1 +++A		+		
Commiphora africana			+++++ +++		+		
Clerodendrum ternatum			A+ A + +		+ 1	1	
Cissus fragilis			+ + 1+ ++				
Acacia robusta			1 + 111		+	1	
Mariscus rehmannianus			+ + +++		+		
Commelina benghalensis			+ + ++		+		
Protasparagus nelsii			+ + + +		+		
Setaria pallide-fusca		+	+ + +		+		
Ceratotheca triloba			+ + ++	+			
Justicia protracta			+ + + +				
Species Group E: Species of the Acacia nigrescens - Grewia flava Tall Open Woodland							
Melhania rehmannii			+	3+ 1 +1 ++1 +++			+ + +
Dipcadi glaucum				+ ++ + +			+
Heliotropium steudneri				+ + +++ + +	+	1	1
Boscia albitrunca				+ + ++++ +	1		
Species Group F: Communal species of the Combretum apiculatum Short Variant of the Acacia nigrescens - Combretum apiculatum Short Closed Woodland and the Acacia nigrescens - Grewia flava Tall Open Woodland							
Aristida congesta subsp. barbicollis			+A+ AA +	A+A1 B1 3+ 34+			3
Tephrosia purpurea			+1+A++ + ++	+AAA++ +++		A+	
Schmidtia pappophoroides			+ ++ +++	+ +++ ++			
Aptosimum lineare			++ + ++ +	++ + ++			

Table 1 Continued

COMMUNITY	1		2			3	
NUMBER		2.1		2.2		3.1	3.2
	2.1.1	2.1.2					
RELEVE	444	223	2323332233422	1311111443122131		4001	0000000
NUMBER	234	252	3091357667148	4821593054801697		6790	1562483
Momordica repens			++ + +	++A+++ 11			
Geigeria ornativa			+ + + +	+A ++1			
Digitaria eriantha			+ + +	+ +++		+	
Dicoma tomentosa			+ +	+ B + ++			
Indigofera alternans			+ +	+ + +++			

Species Group G: Communal species of the Acacia nigrescens - Combretum apiculatum Short Closed Woodland and the Acacia nigrescens - Grewia flava Tall Open Woodland

Indigofera spinescens		+	+	+++ ++++		1	
Endostemon tereticaulis		++	1 ++1 ++	A+ 1 A1+ +			
Aristida rhiniochloa		+	+ A	+ + +B1 +++1		+ 1	
Pavonia burchellii		AAA	1+ + ++	+ + 1 + +			
Euclea undulata		1+	1 ++ +	+11 +			
Ehretia amoena		++	+ +	+ ++ +			+

Species Group H: Diagnostic and dominant species of the Acacia karroo - Acacia mellifera Short Closed Woodland

Acacia karroo				+		3A1+	11+B3+5
Leucas glabrata				+		11 +	+++1+AB
Acacia mellifera				1 +		1A+A	+ 1B1
Urochloa mosambicensis			+	A	+	14	3 A ++
Lycium schizocalyx				1	+	+	+++ +
Cenchrus ciliaris		+	+	+		A	++++ ++
Brachiaria deflexa						3	+1A

Species Group I: Diagnostic and dominant species of the Acacia karroo - Boscia foetida Variant of the Acacia karroo - Acacia mellifera Short Closed Woodland

Chenopodium album		+				+	+ ++1
Justicia flava					+	+	++1B 1
Boscia foetida subsp. minima							+ ++1+
Boscia foetida subsp. rehmanniana							A+++ +
Dicliptera fruticosa			+				++ + +
Cleome angustifolia					+		+ +
Barleria senensis							+ +
Blepharis diversispina							1 +
Blepharis integrifolia							+ +
Cadaba aphylla							+ +
Indigofera sp.							+ +

Species Group J: Communal species of the Acacia karroo - Acacia mellifera Short Closed Woodland and the Acacia nigrescens - Grewia flava Tall Open Woodland

Pupalia lapacea		1	+ +	1 + 1 + + 1+B1	+B35	1 ++111	
Hermbstaedtia linearis			+	+ 1 ++ ++ 1	+A++	114+33B	
Corchorus aspleniifolius			+ + +	+++ ++ +	+++	++ ++	
Tribulus sp.				+ + + +++	+B	A11+	
Tragus berteronianus		+	+ +	+A++++ +B1++ ++	+ +	33A+13	
Setaria verticillata		+ 1	1	+ ++	11	A +++	
Gisekia africana				+++ +	++	+ 1+A +	
Protasparagus suaveolens				+++ +	A	+ ++ 1	
Phyllanthus parvulus		+	+	+ + +		++	

Species Group K: Communal species of the Acacia karroo - Acacia mellifera Short Closed Woodland, Acacia nigrescens - Grewia flava Tall Open Woodland and the Diplachne eleusine - Eragrostis rotifer Closed Grassland Pan

Chloris virgata	3++	+A3	+	B + +++ +1+1+3+	1481	+1	
Corbichonia decumbens	+++	3	+	+ +1 1 1++B	B++	+++++ +	
Eragrostis rotifer	435	++	+	++A+1 +A+++	++	+ +	
Bothriochloa radicans	++	++	1	++ + 4A31 +1	+ +1	+ + +	

Table 1 Continued

COMMUNITY NUMBER	1	2				3	
		2.1		2.2		3.1	3.2
		2.1.1	2.1.2				
RELEVE NUMBER	444 234	223 252	2323332233422 3091357667148	1311111443122131 4821593054801697		4001 6790	0000000 1562483

Species Group L: Communal species of the Acacia karroo - Acacia mellifera Short Closed Woodland and the Acacia nigrescens - Grewia bicolor Short Closed Woodland

Grewia flava		1+A	A +++ +11 +	+AA A3A+A+3BABB1		1+A	+1+11A+
Enneapogon cenchroides		++	1+++++++B+11+	+B++A1B ++++1++		1A 1	++ +BA
Grewia bicolor		ABB	3BA+1AAABA1B+	+B+ +AAA1 1+A1A+		1 +	++1 +1
Acacia tortilis		+A+	1A 11A1+ +	A31 BAB1AA1A111A		1111	+11 1+
Aristida adscensionis		A3+	A++ A+A ++++1	B A+3+ 3B 1443		3A13	+A ++++
Kyphocarpa angustifolia		+	++ ++++++++++	+ +++++ +++1+ ++		+ +	++++
Solanum delagoense	+	B	+ +++1	+1 +++++A++++++		+A31	++ + 1
Achyranthes sicula		B+3	A 1 11 1++++	1 A+A++ ++BA+A		+	+ ++A3
Monechma debile		+++	++++++ ++ ++	+ + + +++1		+++	+ ++

apiculatum and the abundant herbaceous species *Ruellia patula, Eragrostis rigidor* and *Heteropogon contortus*. The woody species *Grewia bicolor* and the forb *Melhania acuminata* (species group A) are also dominant and conspicuous.

The sub-community can be divided into two variants on the basis of species composition and structure, namely, the *Acacia nigrescens* Tall Variant and the *Combretum apiculatum* Short Variant.

2.1.1 The *Acacia nigrescens* Tall Variant

This variant is mostly associated with a diabase dyke (Figure 2) and is distinguished floristically from the *Combretum apiculatum* Short Variant by the absence of species group D (Table 1).

The average density of woody plants is 5124 plants per hectare (Table 2). *Acacia nigrescens* and *Grewia bicolor* are the most abundant woody plants. Tall-growing *Acacia nigrescens* trees are mainly responsible for the higher density of trees in the >6 m height class than in the 3 m and 4 – 5 m height classes, while *Grewia bicolor* accounts for the high density of woody plants in the 0.5 and 2 m height classes (Table 2).

The average total apparent canopy spread for the community is 239%. The much higher canopy spread at the >6 m height interval than at any of the other height intervals, can be attributed to the high density and growth form of tall *Acacia nigrescens* trees (Table 2).

2.1.2 The *Combretum apiculatum* Short Variant

This variant is characterized by species group D (Table 1) which includes the diagnostic and conspicuous woody species *Commiphora mollis, Peltophorum africanum* and *Sclerocarya birrea* and the herbaceous species *Waltheria indica* and *Pogonarthria squarrosa*.

The average density of woody plants is 2092 plants per hectare (Table 3). Despite the lower density of woody plants in this variant than in the *Acacia nigrescens* Tall Variant, there is a higher density of *Combretum apiculatum* (Tables 2 and 3).

The average total apparent canopy spread is 140%. The high density of *Combretum apiculatum* partly accounts for

Table 2 The average number of individuals per hectare and the average total apparent canopy spread in six height classes for woody species in the *Acacia nigrescens* Tall Variant of the *Acacia nigrescens – Combretum apiculatum* Short Closed Woodland

	Individuals per hectare							Percentage canopy spread					
	Height class (m)							Height class (m)					
Species	0.5	1	2	3	4 – 5	>6	Total	0.5	1	2	3	4 – 5	>6
Acacia nigrescens	0	0	133	160	233	758	1284	0	1	16	13	36	100
Combretum apiculatum	0	0	33	7	33	0	73	1	0	4	5	5	0
Ehretia amoena	67	33	0	0	0	0	100	0	0	0	0	0	0
Euclea undulata	133	167	42	0	0	0	342	0	0	0	0	0	0
Grewia bicolor	1300	633	267	79	8	0	2287	4	5	10	8	0	0
Grewia flava	67	67	75	0	0	0	209	2	2	3	0	0	0
Grewia monticola	200	100	333	7	0	0	640	2	2	4	0	0	0
Other species	33	33	41	16	33	33	189	0	0	2	4	6	2
Total	1800	1033	924	269	307	791	5124	9	12	39	30	47	102

the higher canopy spread at the 2 m, 3 m and 4 – 5 m height intervals than at the >6 m height class (Table 3). The low density of tall-growing *Acacia nigrescens* trees and the high density of medium-sized *Grewia bicolor* shrubs also accounts for the high percentage canopy spread at intermediate height classes.

2.2 The *Acacia nigrescens – Grewia flava* Tall Open Woodland

This sub-community is restricted to the Hutton Schorrocks soil type (Figure 2) and is represented by 16 relevés with an average of 28 species per relevé.

The sub-community is characterized by species group E (Table 1) which includes the exclusive forbs *Melhania rehmannii, Dipcadi glaucum* and *Heliotropium steudneri*, and the woody species *Boscia albitrunca*. The grasses *Aristida congesta* subspecies *barbicollis* (species group F) and *Aristida adscensionis* (species group L), and the woody species *Acacia nigrescens* (species group B), *Grewia flava* and *Acacia tortilis* (species group L) are dominant and conspicuous. The dominance of *Grewia flava* in this sub-community and not in the *Acacia nigrescens – Combretum apiculatum* Short Closed Woodland, helps to distinguish the two sub-communities from one another.

Structurally the sub-community can be divided into a tall and short variant.

2.2.1 The *Acacia nigrescens* Tall Variant

The average density of woody plants is 1247 plants per hectare (Table 4). The higher density of trees in the >6 m height class than in the 4 – 5 m and 3 m height classes is as a result of a high density of tall *Acacia nigrescens* trees (Table 4). A few *Acacia nigrescens, Boscia albitrunca, Acacia tortilis* and *Grewia* spp. have grown to between 2.5 and 6 m, but the greatest abundance of woody plants have a height of less than 2.5 m. This is mainly due to the high density of *Grewia* spp., particularly *Grewia flava* (Table 4).

The average total apparent canopy spread is 178%. The canopy spread is at its maximum at the >6 m height class where the density of trees is low, and at its minimum at the lowest height interval where the density of woody species is high (Table 4). This gradual decrease in canopy spread as

Table 3 The average number of individuals per hectare and the average total apparent canopy spread in six height classes for woody species in the *Combretum apiculatum* Short Variant of the *Acacia nigrescens – Combretum apiculatum* Short Closed Woodland

	Individuals per hectare							Percentage canopy spread					
	Height class (m)							Height class (m)					
Species	0.5	1	2	3	4 – 5	>6	Total	0.5	1	2	3	4 – 5	>6
Acacia nigrescens	39	13	4	17	10	59	142	0	0	1	4	8	13
Acacia tortilis	3	2	6	6	8	0	25	0	0	1	1	1	0
Combretum apiculatum	17	13	114	126	136	6	412	1	1	10	13	10	0
Commiphora mollis	2	2	10	3	16	5	38	0	0	0	3	8	3
Dichrostachys cinerea	183	113	42	4	0	0	342	0	1	1	0	0	0
Euclea undulata	35	19	18	0	0	0	72	0	0	0	0	0	0
Grewia bicolor	361	132	122	28	3	0	646	2	4	7	3	0	0
Grewia flava	15	19	16	1	0	0	51	0	0	1	0	0	0
Grewia monticola	69	58	118	37	0	0	282	1	7	8	4	0	0
Other species	21	27	3	0	18	13	82	0	0	1	2	9	3
Total	745	398	453	222	191	83	2092	4	13	30	30	36	27

Table 4 The average number of individuals per hectare and the average total apparent canopy spread in six height classes for woody species in the *Acacia nigrescens* Tall Variant of the *Acacia nigrescens – Grewia flava* Tall Open Woodland

	Individuals per hectare							Percentage canopy spread					
	Height class (m)							Height class (m)					
Species	0.5	1	2	3	4 – 5	>6	Total	0.5	1	2	3	4 – 5	>6
Acacia nigrescens	39	0	13	7	18	110	187	0	0	5	16	37	56
Acacia tortilis	27	12	13	28	10	0	90	0	0	2	3	2	0
Boscia albitrunca	43	2	0	1	1	0	47	0	0	0	0	0	0
Dichrostachys cinerea	89	0	6	5	0	0	100	0	0	0	0	0	0
Grewia bicolor	37	38	22	11	3	0	111	1	2	3	1	0	0
Grewia flava	118	225	210	1	0	0	554	10	18	12	0	0	0
Grewia monticola	100	4	2	25	2	0	132	0	1	2	2	1	0
Other species	2	4	15	2	2	0	25	0	0	1	1	0	0
Total	455	285	281	80	36	110	1247	11	21	25	23	40	56

one comes down the vegetation stratum can probably be attributed to the difference in growth form between the taller trees and the smaller shrubs.

2.2.2 The *Grewia flava* Short Variant

The average density of woody plants is 1934 plants per hectare (Table 5). This variant has a low density of trees taller than 6 m. More than 80% of the woody species occur between ground level and 1.5 m. The species which are most abundant at this height are *Grewia* spp. and *Dichrostachys cinerea* (Table 5).

The average total apparent canopy spread is 74%. The highest canopy spread is at the intermediate height classes (Table 5). This can probably be attributed to the growth form of *Acacia tortilis* trees and mature *Grewia* spp.

3. The *Acacia karroo – Acacia mellifera* Short Closed Woodland

This community is restricted to the Arcadia soil form (Figure 2) (MacVicar *et al.* 1977) and is represented by 11 relevés with an average of 23 species per relevé.

The community is characterized by species group H (Table 1), which includes the diagnostic woody species *Acacia karroo* and *Acacia mellifera*.

The community can be divided into two variants on the basis of species composition and structure, namely, the *Acacia karroo – Boscia foetida* Variant and the *Acacia karroo – Chloris virgata* Variant. The two variants are associated with different soil types (Figure 2).

3.1 The *Acacia karroo – Boscia foetida* Variant

This variant is restricted to the Arcadia Arcadia soil type and is characterized by species group I (Table 1) which includes the conspicuous woody species *Boscia foetida*. The grass *Tragus berteronianus* (species group J) is also dominant and conspicuous.

The average density of woody plants is 1660 plants per hectare (Table 6). The low density of trees taller than 2.5 m and the much higher density of trees less than 2.5 m high, can be attributed to encroachment by *Acacia karroo* juveniles and to an abundance of *Grewia flava* and *Boscia foetida* subspecies *minima*, which seldom grows taller than 1 m (Table 6).

The average total apparent canopy spread is 136%. The high percentage canopy spread at the 3 m, 4 – 5 m and 6 m

Table 5 The average number of individuals per hectare and the average total apparent canopy spread in six height classes for woody species in the *Grewia flava* Short Variant of the *Acacia nigrescens – Grewia flava* Tall Open Woodland

	Individuals per hectare							Percentage canopy spread					
	Height class (m)							Height class (m)					
Species	0.5	1	2	3	4 – 5	>6	Total	0.5	1	2	3	4 – 5	>6
Acacia nigrescens	160	1	3	3	6	12	185	0	0	1	3	4	3
Acacia tortilis	103	27	35	49	20	1	235	1	1	5	7	4	0
Dichrostachys cinerea	260	187	30	15	1	0	493	2	2	2	1	0	0
Euclea undulata	58	73	16	0	0	0	147	0	0	0	0	0	0
Grewia bicolor	285	130	23	18	0	0	456	2	3	3	3	1	0
Grewia flava	88	85	89	1	0	0	263	5	7	4	0	0	0
Grewia monticola	48	21	20	10	2	0	101	1	2	2	1	0	0
Other species	39	8	1	3	3	0	54	0	0	1	1	1	1
Total	1041	532	217	99	32	13	1934	11	15	18	16	10	4

Table 6 The average number of individuals per hectare and the total average apparent canopy spread in six height classes for woody species in the *Acacia karroo - Boscia foetida* Variant of the *Acacia karroo – Acacia mellifera* Short Closed Woodland

	Individuals per hectare							Percentage canopy spread					
	Height class (m)							Height class (m)					
Species	0.5	1	2	3	4 – 5	>6	Total	0.5	1	2	3	4 – 5	>6
Acacia karroo	101	292	39	37	107	151	727	3	4	6	12	43	21
Acacia mellifera	11	2	2	4	13	0	32	0	1	2	3	3	0
Acacia tortilis	11	0	16	7	6	1	41	0	1	2	2	1	0
Boscia foetida ssp. *minima*	362	177	0	0	0	0	539	1	0	0	0	0	0
Boscia foetida ssp. *rehmanii*	0	0	1	6	2	1	10	0	1	4	9	9	0
Grewia bicolor	29	4	12	4	0	0	49	0	0	0	0	0	0
Grewia flava	109	80	39	1	0	0	229	2	2	1	0	0	0
Other species	7	15	3	1	2	5	33	0	0	0	1	1	1
Total	630	570	112	60	130	158	1660	6	9	15	27	57	22

height classes can be attributed to mature *Acacia karroo* and *Boscia foetida* subspecies *rehmannii* trees (Table 6).

3.2 The *Acacia karroo – Chloris virgata* Variant

This variant is distinguished floristically from the *Acacia karroo – Boscia foetida* Variant by the absence of species group I (Table 1). The grasses *Chloris virgata* (species group K) and *Aristida adscensionis* (species group L) are dominant and conspicuous.

The average density of woody plants is 2023 plants per hectare (Table 7). The low density of trees taller than 2.5 m and the much higher density of trees less than 2.5 m high can be attributed to encroachment by *Acacia karroo*, *Acacia mellifera* and *Acacia tortilis* juveniles (Table 7).

The average total apparent canopy spread is 54%. The low density of mature *Acacia* species and the high density of *Acacia* juveniles accounts for the high percentage canopy spread at the 0.5, 1 and 2 m height classes (Table 7).

Ordination

The distribution of relevés along the first and second axes of the ordination is given in Figure 3. A discontinuity in the distribution of the plant communities, sub-communities and variants can be observed. The vegetation gradient of the first axis is associated with a soil texture/moisture gradient (Schmidt 1992), with the *Acacia nigrescens – Combretum apiculatum* Short Closed Woodland and relatively dry sandy soils of the Mispah Mispah soil type on the left and the *Diplachne eleusine – Eragrostis rotifer* Open Grassland Pan and wet clay soils of the Arcadia Arcadia soil type on the right side of the figure. The second axis may also be associated with a soil property gradient (Schmidt 1992), with the *Acacia karoo – Boscia foetida* Variant and black clay soils of the Arcadia Arcadia soil type at the top and the *Acacia karoo – Chloris virgata* Variant and red clay soils of the Arcadia Rooidraai soil type towards the bottom of the figure.

Discussion and Conclusions

The Braun-Blanquet procedure and DECORANA ordination were successfully applied, since clearly defined and ecologically interpretable vegetation units were distinguished.

The results of the ordination suggest vegetation gradients which correlate with soil texture, moisture and colour gradients (Schmidt 1992). Strong correlations between soil type and vegetation in semi-arid environments have frequently been emphasized (O'Conner 1985; Teague & Smit 1992).

Rhino Ranch is situated in the transition zone between Sweet and Mixed Bushveld (Irvine 1941; Acocks 1988). The southern part of Rhino Ranch, the *Acacia nigrescens – Combretum apiculatum* Short Closed Woodland, best fits

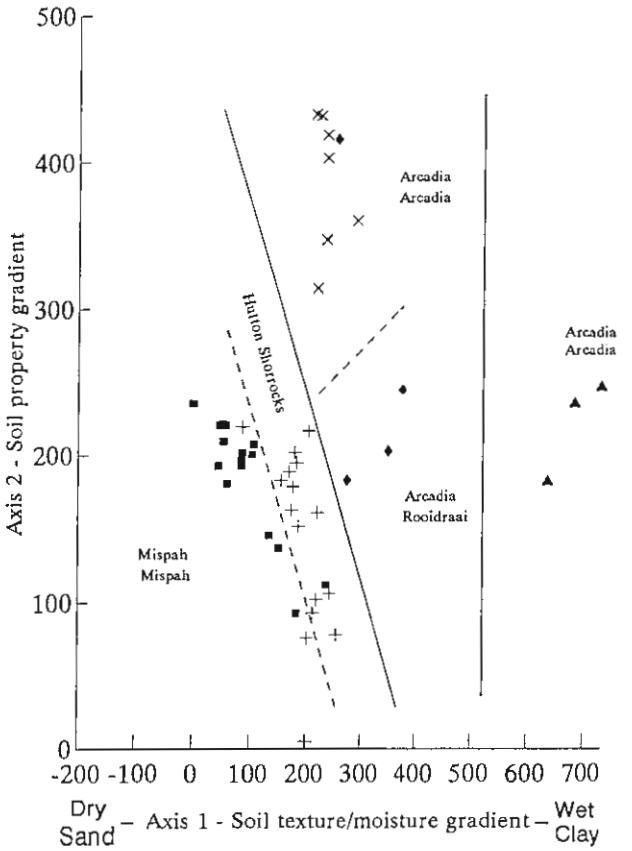

Figure 3 A scatter diagram of the vegetation and associated soil types on Rhino Ranch, north-western Transvaal. Eigenvalues: axis 1: 0.833; axis 2: 0.595. Scale: axis 1 ≠ axis 2. (▲: 1. *Diplachne eleusine – Eragrostis rotifer* Open Grassland Pan; ■: 2.1. *Acacia nigrescens – Combretum apiculatum* Short Closed Woodland; +: 2.2. *Acacia nigrescens – Grevia flava* Tall Open Woodland; ×: 3.1. *Acacia karroo – Boscia foetida* Variant; ♦: 3.2. *Acacia karroo – Chloris virgata* Variant.)

Table 7 The average number of individuals per hectare and the average total percentage canopy spread in six height classes for woody species in the *Acacia karroo – Chloris virgata* Variant of the *Acacia karroo – Acacia mellifera* Short Closed Woodland

	Individuals per hectare							Percentage canopy spread					
	Height class (m)							Height class (m)					
Species	0.5	1	2	3	4 – 5	>6	Total	0.5	1	2	3	4 – 5	>6
Acacia karroo	60	364	789	48	6	2	1269	8	9	7	2	1	1
Acacia mellifera	75	64	70	9	4	0	222	1	2	2	3	1	0
Acacia nigrescens	0	50	0	0	1	1	52	0	1	1	1	1	0
Acacia tortilis	173	122	92	12	5	0	404	2	2	3	2	1	0
Grewia flava	0	11	33	0	0	0	44	2	2	2	0	0	0
Other species	14	8	6	0	3	1	32	0	0	0	0	1	0
Total	322	619	90	69	19	4	2023	13	16	15	8	5	1

the description of the *Combretum apiculatum* Variant of the Mixed Bushveld defined by Acocks (1988) (veld type 18 a1), and the northern part of Rhino Ranch, the *Acacia nigrescens – Grewia flava* Tall Open Woodland and the *Acacia karroo – Acacia mellifera* Short Open Woodland, best fit the description of the *Adansonia* – mixed Thornveld and *Grewia flava* variants of the Arid Sweet Bushveld defined by Acocks (1988) (veld types 14 b and e).

Coetzee (1971) described the vegetation of Rhino Ranch and surrounding areas as *Acacia - Grewia* Veld. He considered this vegetation unit to have an approximately uniform grazing potential. Justification for this classification can be found in the present study. Species groups B, F, G and L (Table 1) indicate a relationship between the Mixed and Arid Sweet Bushveld types on Rhino Ranch (Acocks 1988). *Grewia flava, Grewia bicolor* and *Acacia tortilis* (species group L) and *Acacia nigrescens, Grewia manticola* and *Dichrostachys cinerea* (species group B) are all dominant on Rhino Ranch and were mentioned by Coetzee (1971) as being of the most abundant woody species in the *Acacia – Grewia* veld. The most abundant herbaceous species were given by Coetzee (1971) as *Aristida congesta, Enneapogon cenchroides, Urochloa mosambicensis* and *Eragrostis rigidior. Aristida congesta* and *Enneapogon cenchroides* were dominant on Rhino Ranch, together with *Aristida adscensionis* and the forbs *Melhania acuminata* and *Achyranthes sicula*. The dominance now of only unpalatable pioneer grasses and forbs may be an indication of veld degradation since the survey by Coetzee (1971).

To the west of Rhino Ranch in the Steenbokpan region (23°30′ and 24°00′ S and 27°00′ and 27°30′ E), Van Staden (1992) classified vegetation units akin to those of the *Acacia nigrescens – Combretum apiculatum* Short Closed Woodland and *Acacia nigrescens – Grewia flava* Tall Open Woodland on Rhino Ranch. Van Staden (1992) is of the opinion that the *Combretum apiculatum* Variant of the Mixed Bushveld defined by Acocks (1988) (veld type 18 a1) could be classified as Arid Sweet Bushveld. This would imply that all the vegetation on Rhino Ranch could be classified broadly as Arid Sweet Bushveld.

Superimposing the vegetation and soil maps for Rhino Ranch helped define three areas uniform in soil form and floristic composition (Schmidt 1992):

(a) Veld dominated by the *Acacia nigrescens – Combretum apiculatum* Short Closed Woodland on the Mispah soil form.
(b) Veld dominated by the *Acacia nigrescens – Grewia flava* Tall Open Woodland on the Hutton soil form.
(c) Veld dominated by the *Acacia karroo – Acacia mellifera* Short Closed Woodland on the Arcadia soil form.

These units (compare Figure 1) should serve as suitable management units in which to monitor key environmental parameters central to the philosophy of Adaptive Management (Walters & Hilborn 1978; Holling 1978) which is generally recommended for game ranches in semi-arid rangelands (Grossman 1988).

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